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ABSTRACT

A study focusing on the serious need for active programs in improving the cognitive skills of hearing-impaired students is examined. Six hypotheses are presented as potential outcomes of using the Instrumental Enrichment (IE) program (classroom intervention for adolescents and adults using content-free paper and pencil exercises to correct deficient cognitive functions and provide the prerequisites for learning and problem solving). Some 91 experimental hearing-impaired college students were compared with 91 matched controls. The hypotheses are that the IE students will: (1) demonstrate significantly higher logical reasoning than the controls; (2) demonstrate significantly better achievement in reading comprehension; (3) math concepts; and (4) mathematical computation as measured on the Stanford Achievement Test, Hearing-Impaired version; (5) demonstrate improved organization in the production of a written essay; and that (6) within the experimental group, students whose hearing loss dates from age 2 or before will show significantly greater improvement in scores in logical reasoning. Experimental students received IE focusing on generalizable cognitive skills during the experimental period. Conclusions from the study include the following: the gains in logical reasoning, math concepts, and math computation and reading comprehension were significantly higher for the IE group; all hearing-impaired college students can benefit from cognitive skills instruction; trained IE instructors tend to persist in their interest in implementing the teaching of thinking skills; and whenever possible, cognitive skills instruction should begin at an earlier age than college. Tables are included. Contains 20 references. (SM)

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Cognitive Enhancement of Hearing-Impaired Post-Secondary Students

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ABSTRACT

This investigation focused on the serious need for active programs in improving the cognitive skills of hearing-impaired college students. Ninety-one entering students at Gallaudet University were identified as experimental students, and were matched with 91 students as controls for the experiment. Experimental students received systematic instruction focusing on particular generalizable cognitive skills during the experimental period, several times per week, in the contexts of their regular college classes. Instructors of the experimental group were given special training over a two-year period in the methodology of the program, Instrumental Enrichment.

Results indicated that cognitive instruction of this nature produced statistically significant improvement for experimental subjects in tests measuring logical reasoning, reading comprehension, math concepts, and math computation.

A process analysis of interviews with individual experimental students and their instructors also indicated that students began to demand more verbal elaboration, to become more careful in checking for error in their work, and to ask for verification from each other on points made during classroom discussions.

Recommendations are made for expanding systematic cognitive skill instruction in universities; systematic training of college instructors was concluded to be a fundamental prerequisite for the implementation of such programs.

INTRODUCTION

Background

Results of recent National Assessment of Educational Progress Tests (NAEP) indicate that students on a national level are faltering in problem-solving skills. Instructors who work with hearing-impaired students frequently express concern and frustration about their students' deficiencies in problem-solving skills, and in understanding and manipulating higher order concepts and abstractions, as indicated in both classroom and written work. That concern often relates to difficulty with such critical cognitive skills as: manipulating more than one variable,

conceptualizing the meaning of a written work, forming conclusions, dealing with hypothetical data, and spatial reasoning.

Yet, research with hearing-impaired persons has documented that there are no basic differences between their range of cognitive abilities and that of the general population, and that any inferiority in cognitive performance may be accounted for by experiential and linguistic deficits as well as by communication handicaps (Levine, 1976).

During recent years, however, a specially developed program entitled Instrumental Enrichment (Feuerstein, 1978) has become available in the United States. This classroom intervention program for adolescents and adults uses content-free paper-and-pencil exercises to correct deficient cognitive functions and provide the prerequisites for learning and problem-solving, such as analytic perception, projection of virtual relationships, orientation in space, comparison, temporal relationships, hierarchical relationships, syllogistic thinking, categorization, synthesis, and sequential progression.

Review of the Literature

Studies in cognition in hearing-impaired persons have been numerous in the past. After an initial period of research focusing on I.Q., the center of attention now is on the processes involved in cognition and perception. It appears to be generally accepted that hearing-impaired persons have the normal range of intelligence when tested on the performance, rather than the verbal, subtests of various I.Q. instruments (Drever & Collins,1928; Vernon, 1968). When the influence of age is controlled,statistical data on hearing-impaired children indicate strong relationships between achievement test scores and variables such as age-of-onset of hearing loss,

cause of loss, degree of loss, additional handicapping conditions,ethnic background, and type of special educational program (Jensema, 1975).

The literature on the improvement of cognitive skills in the college-age learner strongly supports the efficacy of specific and planned training in those skills. Even minimal training in cognitive strategies has resulted in long-term benefits in hearing college-level students (Dansereau, et al., 1975). The literature demonstrates that cognitive skills training is effective (Weinstein, 1977; Weinstein, et al., 1980; Weinstein, et al., 1981).

If we accept the fact that certain specific cognitive deficiencies do exist for hearing-impaired persons but that no evidence suggests less than the normal range of intellectual potential among them as a general group, then itis apparent that a specific program of activity in an educational setting holds significant promise for improvement of these critically important generic skills. In addition, a program which was originally developed to improve the performance of disadvantaged hearing learners who had some of the same deprivation of thinking skills opportunities as hearing-impaired learners, may well be specifically the type of program which is adaptable for this special purpose.

Martin and Jonas (1986) studied the effects of Instrumental Enrichment with an experimental and a control group of hearing-impaired adolescents over a two-year period. The program requires teachers to use specific paper-and-pencil exercises on such cognitive skills as comparison, analysis, classification, and sequence, and to mediate students' reflection on the cognitive strategies they have used (metacognition), and then helping them to make applications (bridging) to the subject matter under study. Special in-depth teacher training is needed to implement the program. Results included significant improvement in tests of reading comprehension, mathematics computation, mathematics concepts, logical reasoning, as well as

the observed application of greater detail, better organization, and greater precision in posed problem-solving situations. Teachers not involved with the implementation also reported that Instrumental Enrichment students in their classes demonstrated improved attention to detail and a tendency to explore alternatives to solutions to a problem in the subject matter context, as compared to students who had not had this intervention. These results have been replicated in a study by Craig (1987) in another school, using the same approaches with similar methods of assessment. Similar results were noted in an application to the college-age hearing-impaired learner in another study using the same methodology and the same program (Martin and Jonas, 1987).

Another investigation (Keane and Kretschmer, 1987) found that the Feuerstein approach of mediated learning as outlined above also resulted in significant transfer of learning on other cognitive and behavioral measures not associated with the teaching method itself (Instrumental Enrichment).

Another study (Krapf, 1985) with deaf adolescents using mediated learning experiences similar to Instrumental Enrichment demonstrated that this approach has a measurable and positive impact on figural analogic reasoning; it was also found that deaf adolescents as a result of this methodology can use two or more sources of data if mediation takes place, and students were found to be capable of using metacognitive problem-solving skills in the sense of being able to explain why certain strategies did or did not work. The results of this study also demonstrated that deaf adolescents after mediation will use symbols and operations that reflect symbolic relational thought--that is, formal operational thinking. Still another study with Instrumental Enrichment and deaf adolescents at the North Carolina School for the Deaf

(Heywood and others, 1988) found significant positive effects on students' reasoning aptitudes, although sharing inconsistent effects on achievement in academic career.

METHOD

Hypotheses

The following hypotheses were advanced as potential outcomes of using the Instrumental Enrichment Program with the experimental vs. control samples of hearing-impaired college students: 1) Demonstrate significantly higher logical reasoning as measured by the Raven's Standard Progressive Matrices (Raven, 1960). Demonstrate significantly better achievement in 2) reading comprehension, 3) mathematics concepts, and 4) mathematical computation as measured on the Stanford Achievement Test, Hearing-Impaired version (SAT-HI) (Madden, 1972). 5) Demonstrate improved organization in their production of a written essay as judged by a team of trained independent judges. 6) Within the experimental group, students whose hearing loss dates from age 2 or before will show significantly greater improvement in scores in logical reasoning as measured by the Raven's Matrices, when compared with students whose hearing loss dates after age 2.

General Procedures

The training procedure for instructors involved six full-days of instruction in the cognitive materials for each year of the two-year Project. Thus, the instructors themselves experienced cognitive modification as they prepared to provide Mediated Learning Experiences

(MLE) for their own students. An example of one MLE sequence in which instructors were trained, was as follows:

1. The instructor in an English course had students compare pairs of words with similar meanings, and then to delineate the specific differences and similarities between the words.

2. The instructor then discussed with the students the mental processes which they used to solve these problems (looking at the entire problem first; fine discrimination between words that appear to have the same meaning; keeping in mind several sources of information; using what is known, what is seen, and what can be inferred; and checking for error). This discussion was considered metacognitive.

3. The instructor next discussed with students how that particular skill of comparison could be applied (or "bridged") to the subject matter of the course, e.g., in English--comparison of two characters in a narrative, comparison of two pieces of writing which are designed to communicate the same message, comparison of two modes of communication for the hearing-impaired learner.

4. Finally, the instructor later in the context of the English course referred back to the skills of comparison learned from these exercises, as a way of reinforcing the importance of the comparison process.

During academic year 1985-86, experimental students had regular (at least 90 minutes per week for 30 weeks) instruction in the Instrumental Enrichment program, focusing on the six cognitive skills of: projecting virtual relationships, orientation in space, analytic perception, comparison, creating and following instructions, and categorization.

During the academic year 1986-87, participating subjects had regular instruction in the cognitive skills of temporal and spatial relationships, numerical progressions, hierarchical relationships, synthesis, and logical reasoning. Intervention occurred in the context of regular course work in English and Math by regular instructors who had special additional training in the IE program as discussed above.

Groups

In the Fall of 1985 (Year One), 91 experimental subjects were identified in the classes of the seven experimental instructors who made a commitment to training in the methods of IE--the experimental treatment. Ninety-one control subjects were also identified, matched on age-of-onset of hearing loss, degree of hearing loss, and gender. As a result of naturally-expected student attrition at the college level, four different lengths of experimental intervention exposure occurred--a four-semester experimental group, a three-semester experimental group, and two two-semester groups (1985-86 and 1986-87).

In the Fall of 1986 (Year Two), identifications were made of those individuals in the original control group who had returned to college; a rather large number of control subjects did not return for their second year (reduction was noted from 91 to 55). The same assessment was made of the experimental subjects from the first year, and again, some considerable attrition occurred (from 91 to 75). The control group, of course, consisted of individuals who throughout the two-year period had no exposure to the experimental treatment.

Criterion Measures

Demographic data were collected on all experimental and control subjects in the Fall of 1985, including: age-of-onset of hearing loss, unaided decibel loss in the better ear, and gender. Pre-tests were administered to both groups, including: Raven's Standard Progressive Matrices (Raven, 1960), the Gallaudet University Reading and Writing Placement Tests, the Effective Study Skills Test (Brown, 1964), the Study Skills Survey (Brown, 1983), and the Self-Concept as a Thinker Survey (Martin, 1981); in addition, scores on entering students on the Stanford

Achievement Test Hearing-Impaired (SAT-HI) (Madden, 1972) were obtained for the subtests of Reading Comprehension, Math Concepts, and Math Computation.

Post-test measures administered to both experimental and control subjects were: the Raven's Standard Progressive Matrices; the SAT-HI subtests on Reading Comprehension, Math Computation and Math Concepts and the Gallaudet University Reading and Writing Tests; in addition, individual interviews of 20 randomly selected experimental students, and interviews with all experimental group instructors took place at the end of the experimental period.

Data Treatment

Student data on a series of measures was included for analysis both at pre- and post-test administration. Pre-test data were available on sex, hearing loss, measures of study and thinking skills and various reading, writing and math tests. These pre-test measures were all compared for similarity between IE and Control groups using Chi-Square or t-tests where appropriate. In an attempt to determine the relative importance of IE versus Control group designation as well as sex of student, age-at-hearing-loss and dB-loss on outcome measures, an overall general linear model (GLM) entering these factors and their interactions was considered. Due to the level of missing data that occurs in these data, however, it was not possible to run one overall analysis including these factors since the intersection of missing data was in excess of 70% of all available cases at pre-test time. As an alternative approach, each of the factors listed above was considered individually as a predictor of the Ravens and SAT-HI tests. While not as powerful as the former approach, this method does include the majority of cases for each measure and does offer some insight into their effects on the outcome measures. Interactions were then analyzed when two or more of these main effects were significantly related to the

outcome measures. For the Raven's post-test the general linear model was used to compare Control and IE groups after accounting for differences in pre-test means. For the SAT-HI subtests, analysis of variance (ANOVA) was used for post-test only due to large missing data at pre-test administration (see Table 1). For cases where pre-test information was available, Control and IE groups were statistically comparable. However, lack of complete pre-test information cannot guarantee this appearance of relatively equivalent grouped pre-test means.

RESULTS

As has been previously mentioned, one limitation of the present study was the mobility of this college-aged population which allowed little control over how many students would comprise the final study sample size for the measures administered as well as the amount of IE exposure. Consequently, it was important to measure the degree to which the Control versus IE groups remained comparable on the original set of factors thought to be important for matching characteristics between these two groups. Table 1 presents the series of characteristics for the final study sample. For all variables listed in this table as well as most variables in subsequent tables, group sample sizes representing non-missing data are presented. This point is important since these values sometimes change markedly, thus affecting interpretation of the results presented.

Table 1 presents two hearing-loss measures--specifically age-at-onset of hearing loss, dB loss in better ear, the participant's sex, three measures of the student's study and thinking skills and six measures of aptitude and achievement. For all measures presented, there were no significant differences found between the Control and IE groups. The largest group variations

were found in the age-of-onset of hearing-loss measure--which shows a 5% discrepancy in the IE versus Control group comparison and in the sex variable which showed a 10% discrepancy. In either case, these differences were deemed acceptable by the fact that differences between IE and Control groups were non-significant, as well as the fact that there was still ample representation of all sub-categories of variables in both groups. In addition, the three measures of study and thinking skills are all very close, indicating comparable levels between IE and control groups. The six aptitude and achievement measures include: 1) Raven's progressive matrices, 2) SAT-HI Reading Comprehension, 3) SAT-HI Math Computation, 4) SAT-HI Math Concepts, 5) Gallaudet Placement Test - Reading, and 6) Gallaudet Placement Test - Writing. As mentioned earlier, outcomes on these pre-measures are all statistically equivalent. Three points should be emphasized. First, three of these six measures (SAT-HI Reading Comprehension and the two Gallaudet placement tests) measure aspects of language acquisition and ability. Based on the relative closeness of the IE and Control means, especially with regard to the placement tests, it appears that these two groups are comparable. Second, there was marked missing data among the SAT-HI battery on the pre-test. These data can therefore only tentatively imply comparability between IE and Control groups and prohibit their use in post-test analysis. Finally, there was complete Ravens pre- and post-test information available for 73 of the 130 subjects, and the analysis in Table 2 is based on these 73 cases. We therefore concluded that the final study sample size was an adequate representation of the original sample and that matching between the IE and Control groups remained intact.

Table 2 presents the pre, post, and difference score means for the Raven's Standard Progressive Matrices. The results show that for the first comparison, IE students significantly gained more than control students, averaging 1.9 points to the control group's 0.7 points, after

controlling for the effects of the pretest. A second comparison revealed no trend between two and four semester IE groups. Hence, Hypothesis One is supported in that gains for the IE students are significantly greater than that for the controls on a measure of logical reasoning.

Table 3 presents the SAT-HI Reading Comprehension results for the post-test administration. For this table and Tables 4 and 5, insufficient pre-test information was available. Based on prior arguments and previous research we assumed that matched samples among hearing-impaired students are relatively comparable among such standardized tests (Martin & Jonas, 1986). The results indicated significantly higher scores for the IE group (634.9) versus the control group (621.4). The two- to four-semester comparison of IE exposure showed no significant pattern within the experimental sub-groups. Hypothesis Two was therefore supported in that the IE group does significantly better in reading comprehension than the control group. Scaled, rather than grade-equivalent, scores are compared because they are invariant across different SAT-HI test level administrations.

Table 4 presents the SAT-HI Math Concepts post-test means. The results showed that (1) IE students scored significantly higher than control students (698.9 versus 678.1) and (2) that four-semester IE students score significantly higher than two-semester students (720.1 versus 690.5). This result was expected since the contents of the Math Concepts test require the students to use principles of logic and analogic activities which occur repeatedly throughout IE instruction and more frequently as IE instruction moves into the second year. Hence, Hypothesis Three was strongly supported in that both the presence and duration of IE instruction have a significant impact on performance in Math Concepts.

Table 5 presents the SAT-HI Math Computation post-test means. The results show significantly higher scores for the IE group (711.7) as compared to the control group (689.0).

The two-to-four semester comparison shows higher scores for the four-semester group (726.5), versus the two-semester group (707.5), but this comparison did not reach statistical significance. Hence, Hypothesis Four was supported in that the IE group as a whole demonstrated significantly better performance in math computation in comparison with controls.

On the Gallaudet University Writing Placement test, which is a test of grammatical usage, word choice, and organization, the data do not show any significant differences between the IE and control groups. The comparison between two- and four-semester IE groups does approach statistical significances ($p = .0891$). Hence, Hypothesis Five cannot be supported. Results on the Gallaudet Reading Placement tests also do not show any significant differences between IE and Control groups.

As previously discussed, analyses of the Ravens and SAT-HI tests were conducted by using age-at-onset of hearing loss, dB loss in better ear, and sex successively as predictors. These analyses indicated that the two hearing loss measures did not significantly predict performance differences between IE and Control groups. The relationship of sex of student to performance, however, was significant for the two math subtests of the SAT-HI.

Table 6 presents selected two-way Analysis-of-Variance Models for the outcome measures that were found to be significantly different in these other analyses. The first series in this table models the Raven's test for combinations of the IE group variable with age-of-onset of hearing loss, so as to address Hypothesis Six. As shown, the data in Table 6 do not support this hypothesis, instead showing no significant differences between the four sub-group combinations listed for this measure of logical reasoning. The second series presents the Raven's test for the combinations of IE males and females and control males and females. The table shows that IE males tended to out-perform the control males. The third and fourth series

presents the same model for the SAT-HI Math Concepts and Math Computation tests. The IE males tended to out-perform the other three groups listed.

Carry-over Effect

The original grant proposal for this project indicated that the implementation would occur over a two-year period, first with a group of entering students and their instructors, and then with that same group of students in their second year and their instructors at that time.

The question arose, "What persisting change, if any, can be seen among the first-year instructors after they were no longer required to implement the thinking skills program?" That question is not easily answered. However, during 1986-87, while the experimental group was in their second year, the investigator examined the activity of first-year instructors (from 1985-86) as they began to teach a new entering group of students (who were not a part of this experiment). These instructors chose to continue their own training in IE in second-year instruments and also voluntarily implemented IE with their new group of entering students. A longitudinal question which should be investigated in a follow-up study is, "What measurable cognitive effects would be found in the experimental group after two or more semesters of no further intervention?"

Analysis of pre- and post-test results in 1986-87 in first-year algebra-a subject taught by two of these instructors--in comparison with other algebra classes taught by non-IE instructors indicated a statistically significant difference ($p < .01$) in favor of the students in these two experienced IE instructors' classes. No differences in student achievement had been noted between the students of the experimental or IE instructors and non-IE instructors in years prior to the study.

Interview Data

As originally planned, the investigators also interviewed randomly selected experimental subjects as well as the instructors in the experimental group. These data are used to assist in the interpretation of the statistical findings and to broaden the base of information on the results of the experiment beyond paper-and-pencil instruments.

1. Students

The student interviews took place during Spring 1987, well into the final semester of the experimental treatment. Students were asked to respond to the question, "In what ways have you changed your thinking since you started to use Instrumental Enrichment?" Five students of the twenty randomly selected experimental subjects responded that they were not aware of any change; an additional two students expressed only that they were concerned with the amount of time that Instrumental Enrichment seemed to "take away" from learning English. The remaining 13 students all replied in some form that they believed that their thinking patterns had become more careful or systematic or less impulsive. A sampling of the responses of this latter sub-group are presented below to demonstrate the support for this interpretation:

Student	Statement
A.	"I found that I started to slow down before I guessed at an answer to a problem."
B.	"I think I started to look at the whole thing instead of the parts of a problem."
C.	"I think IE has been good for me--I can think better."
D.	"It takes me a little longer, but I think I get more right answers now."
E.	"I try to look for the reasons underneath the answers now before I write an answer."

2. Experimental Instructors

During the interviews with the experimental instructors, the key question was, "What types of responses to the program did you see happening in your students in the experimental group?" Instructor responses to this question helped to elaborate further on the above student responses. Among the instructors' observations was the clear trend that experimental students by the period of March 1987 began to demand that their instructors give them further verbal elaboration on any response, thus reflecting the same elaborative style that the instructor had been trying to model for them. For example, students were reported by experimental instructors to demand this reasoning both from each other and from the instructor with words such as:

A. "Explain it to me, please."

B. "Give me the evidence for that."

C. "Could I have another example, please?"

D. "I think I have the idea; let me give you an example and see if I know it now."

E. "How does that connect with what I already know?"

Instructors reported that no such demands were made by experimental students during the first semester of the experiment. Students were also reported by experimental instructors to argue with one another over points during class, whereas previously they had merely accepted what the instructor had said or what each other said without question. It is clear from these sets of quotations that verbal elaboration behaviors were enhanced by the program; no such responses were reported from students in non-Instrumental Enrichment classes by experimental group instructors.

The second key question in the interviews of IE faculty was, "What overall changes do you see as a result of the experiment?" The following points were made by IE faculty interviewees:

A. Students in the experimental group began to feel the "strength" of their reasoning powers.

B. The students in the experimental group moved further ahead into higher-level English and Math than had been the case in previous years with similar groups that did not have Instrumental Enrichment.

C. Students demonstrated more confidence in themselves during examinations.

D. Students began to be able to use more than one piece of information at a time in activities requiring that behavior.

E. Test scores on teacher-made tests demonstrated that students had begun to "reason better."

F. Students stopped giving up on difficult academic problems or being depressed about their difficulty.

G. Students became better notetakers; they began to ask the instructor to stop and allow them to take notes instead of the instructor having to stop and remind them to take notes (this is an important issue in teaching deaf students, who are normally not able to take notes during a lecture because of the need for visual attending).

H. Students at first resented the non-verbal materials in the program because they felt that they were for younger students; but by the end of the third semester, they expressed that they saw the value of those and began to ask for more practice in the non-verbal instruments as well as in the verbal instruments.

I. Instructors said that they believed their own style of teaching had changed permanently as a result of the training in the direction of: allowing more "wait-time" for student responses in discussions, using more cognitive terms in their teaching, and demanding higher-level responses from their students during discussions.

Thus, these data also demonstrate that important changes were taking place beyond what was noted in the test scores reported earlier.

COMPOSITE CASE STUDY ANALYSES

A further investigation of the data was undertaken to more specifically determine who among those students in the IE group did particularly well with the IE training. To answer this question, one method is to look at some percentage of the upper score distribution among those outcome test measures that were found to be significantly higher for the IE group as a whole. Since there was still considerable variance around the group mean of the IE group on these measures, this approach has the advantage of localizing those students who all did well on these measures and then reporting which attributes they possessed. For instance, for the entire sample of IE and control cases having valid pre- and post-test Raven's data (N=73), only 42 out of the 73 (57.5%) gained at all (1 or more points). Among the control group alone, only 15 out of 33 (45.4%) gained ground. Among the IE group 27 out of 41 (65.9%) gained from pre- to post-test. This finding, however, further varied according to length of exposure. Among those students who had some IE training but less than the full two years of exposure, 11 out of 21 (52.4%) gained on the Ravens test. Among those students with the full two years of exposure, 16 out of 20 (80.0%) gained from pre- to post-test on the Ravens.

Consequently it might be of interest to profile this group of 27 "gainers" and compare them to the IE group as a whole. This group is quite comparable to the IE group overall with regard to Age-At-Onset of Hearing Loss, dB Loss in Better Ear, and Sex. This point implies that students from all categories of these measures are represented in this "gainer-only" group. Similarly, the scores on the three measures of students' study and thinking skills were all quite close to the overall group, again demonstrating that students who self-rate high, low, or average

were represented among the gainers. The average Pre-Test Raven's Score was 44.3 as compared to 44.9 for the entire IE group. Their average Post-Test score was 49.0, representing an average gain of 4.7. Thus, we see that students with high, low, or average Pre-Test scores on the Ravens were represented in this gainer group. Their Reading Comprehension Post-Test Scores were quite comparable to the overall group, but both Math Scores were higher -- Concepts - 710.7 vs. 698.9 and Computation - 725.0 vs. 711.7. Thus, the attributes that "gainers" share in common are: 1) a tendency to have completed the full two years of IE exposure and 2) a tendency to perform higher on SAT-HI Math subtests than did the IE group overall.

SUMMARY AND CONCLUSIONS

As the result of the experiment, the following results and conclusions are offered:

1. The gains in logical reasoning, math concepts, and math computation and reading comprehension were significantly higher for the IE group as compared to the control group.

2. Length of IE exposure (two versus four semesters) significantly favored longer exposure.

3. All, not some, hearing-impaired college students can benefit from cognitive skills instruction; the positive changes noted in experimental subjects were general and not limited to those whose pre-test scores or individual characteristics fell in any low, middle, or high range.

4. In the entire group (both IE and control combined), males scored higher than females in logical reasoning pre- and post-test, but both sexes gained the same amount of points. Males also outscored females in Math Concepts and Computation.

5. Looking at the IE group only, males performed better than females in the Math Concepts and Math Computation.

6. For the young adult learner in the collegiate environment, a systematic cognitive skills program places the student in situations where they can begin to feel that they can think, which is an important factor in their self-confidence as learners. This conclusion

is especially critical in terms of the deaf college student, who frequently has a problem with self-confidence in comparing himself or herself with hearing students.

7. No significant alterations of sequence in cognitive skills instruction were needed for adapting cognitive-skill programs for hearing-impaired, as compared with hearing college students.

8. This program of systematic cognitive instruction leads students to mediate for each other, to the point where this peer mediation gradually becomes a supplement to the mediation carried out by the instructor.

9. Instrumental Enrichment as an intervention may assist in making some of the linkages between the visual and the verbal code systems for the hearing-impaired learner; this conclusion was based on the observed easy interaction back and forth between those two modalities on the instruments as noted by experimental-group instructors, by comparison with their observations of the same students at the beginning of the experiment. Once again, this conclusion is fundamentally important in regard to the hearing-impaired college student who must make transitions on a regular basis between those two modes if he or she is to be successful in the collegiate learning environment and in the world beyond college.

10. The implementation of a cognitive skills instruction program at the college level is made administratively difficult by the flexible scheduling and optional course election that is permitted; systematic ensured instruction in cognitive skills is far more difficult in that environment than in the secondary school. Cognitive skills instruction should therefore be made a regular part of at least one course in any hearing-impaired college student's program so that all students have this systematic experience.

11. Trained IE instructors tend to persist in their interest in implementing the teaching of thinking skills.

12. Wherever possible, cognitive skills instruction should begin at an earlier age than the college age so that college environments can reinforce rather than teach for the first time these essential skills. Colleges should take the leadership in promoting this instruction in secondary and elementary schools.

13. While it is administratively efficient to have cognitive skills instruction be the responsibility of one single academic department in which students must take courses (e.g., English), it is far better to have cognitive skills instruction embedded across all subjects and across a number of departments to which students will have exposure. If departments work in a complementary manner in regard to the responsibility for cognitive skills instruction, the burden is spread and the student benefits by seeing the connections of generic cognitive skills to a variety of subject areas.

Educators of the hearing impaired have for many years been concerned with raising the cognitive performance of their students. Systematic implementation of a specially-developed cognitive education program with in-depth faculty development appears to be an appropriate approach to this problem. It is essential that educators of hearing-impaired students at all levels, but especially at the college level, now take note that the cognitive potential of such students can indeed be raised--this conclusion is the most essential and hopeful one for the future of the hearing-impaired learner.

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Table 1.

Selected Background Characteristics of the Final Cognition Study Sample--Overall Sample and Subdivided by Control vs. IE Group Participation* (Group Sample Sizes with Non-Missing Data)

	Overall Sample (130)	IE Group (75)	Control Group (55)
Age at Onset of Hearing Loss - % < 2 years	69.3 (70)	67.2 (41)	72.5 (29)
% ≥ 2 years	30.7 (31)	32.8 (20)	27.5 (11)
dB Loss in Better Ear			
% < 70 dB	25.8 (15)	24.4 (10)	29.4 (5)
% 70-90 dB	27.6 (16)	29.3 (12)	23.5 (4)
% > 90 dB	46.6 (27)	46.3 (19)	47.1 (8)
Sex - % Males	50.4 (63)	55.7 (39)	43.6 (24)
% Females	49.6 (62)	44.3 (31)	56.4 (31)
Study Skills Survey Score Pre-Test Mean	27.4 (93)	28.5 (46)	26.3 (47)
Effective Study Skills Test Score Pre-Test Mean	63.4 (93)	63.4 (46)	63.4 (47)
Thinking Skills Survey Score Pre-Test	25.7 (99)	25.9 (51)	25.4 (48)
Ravens Pre-Test Mean	44.0 (73)	44.9 (41)	42.8 (32)
SAT-HI Reading Comprehension Pre-Test Mean	641.8(25)	650.6(11)	634.9(14)
SAT-HI Math Computation Pre-Test Mean	716.3(26)	708.5(12)	723.0(14)
SAT-HI Math Concepts Pre-Test Mean	689.8(22)	681.8 (8)	694.3(14)
Gallaudet University Reading Placement Pre-Test Mean	37.8(106)	38.6 (57)	36.9 (49)
Gallaudet University Writing Placement Pre-Test Mean	46.1(109)	46.0 (61)	46.1 (48)

* No significant differences were found comparing IE to Control group.

Table 2.

Pre, Post, and Difference Score Means on Raven's Standard Progressive Matrices

	Pre	Post	Difference
Overall Sample (N=73)	44.0	45.3	1.3
Controls (N=32)	42.8	43.5	0.7
Experimentals (IE) (N=41)	44.9	46.8	1.9
IE Group #1 - 2 semesters (Fall 1986, Spring 1987) (N=12)	43.9	47.2	3.3
IE Group #2 - 2 semesters (Fall 1985, Spring 1986) (N=14)	44.6	46.1	1.5
IE Group #3 - 3 semesters (Fall 1985, Spring 1986, Fall 1986) (N=4)	50.0	48.0	2.0
IE Group #4 - 4 semesters (Fall 1985, Spring 1986, Fall 1986, Spring 1987) (N=11)	44.5	46.8	2.3

GLM comparing controls to all IE students on post-test
F = 4.0377 p = .0483

GLM comparing 2 semesters versus 4 semesters of IE exposure
F = .0127 p = .9108

Table 3.

SAT-HI Reading Comprehension Post-Test Means for Controls, IE Students, and for Each IE Group

	Scaled Score	Grade Level Equivalent Score
Overall Sample (N=69)	629.2	4.9
Controls (N=29)	621.4	4.5
Experimentals (IE) (N=40)	634.9	5.0
IE Group #1 - 2 semesters (Fall 1986, Spring 1987) (N=12)	633.6	5.0
IE Group #2 - 2 semesters (Fall 1985, Spring 1986 (N=13)	633.5	5.0
IE Group #3 - 3 semesters (Fall 1985, Spring 1986, Fall 1986) (N=4)	637.8	5.1
IE Group #4 - 4 semesters (Fall 1985, Spring, 1986, Fall 1986, Spring 1987) (N=11)	636.9	5.1

ANOVA comparing controls to all IE students
F = 4.3954 p = .0398

ANOVA comparing 2-semesters versus 4-semesters exposure
F = .0973 p = .7570

Table 4.

SAT-HI Math Concept Post-Test Means for Overall Sample, Controls, All IE Students, and for Each IE Group

	Scaled Score	Grade Level Equivalent Score
Overall Sample (N=70)	690.3	8.0
Controls (N=29)	678.1	7.4
Experimentals (IE) (N=41)	698.9	8.5
IE Group #1 - 2 semesters (Fall 1986, Spring 1987) (N=12)	689.9	8.0
IE Group #2 - 2 semesters (Fall 1985, Spring 1986 (N=14)	691.1	8.0
IE Group #3 - 3 semesters (Fall 1985, Spring 1986, Fall 1986) (N=4)	695.2	8.3
IE Group #4 - 4 semesters (Fall 1985, Spring, 1986, Fall 1986, Spring 1987) (N=11)	720.1	11.0

ANOVA comparing controls to all IE students
F = 6.6722 p = .0119

ANOVA comparing 2 semesters versus 4 semesters exposure
F = 5.7158 p = .0223

Table 5.

SAT-HI Math Computation Post-Test Means for Overall Sample, Controls, All IE Students, and for Each IE Group

	Scaled Score	Grade Level Equivalent Score
Overall Sample (N=70)	702.3	8.6
Controls (N=29)	689.0	7.9
Experimentals (IE) (N=41)	711.7	9.7
IE Group #1 - 2 semesters (Fall 1986, Spring 1987) (N=12)	708.3	9.1
IE Group #2 - 2 semesters (Fall 1985, Spring 1986 (N=14)	706.9	8.9
IE Group #3 - 3 semesters (Fall 1985, Spring 1986, Fall 1986) (N=4)	697.5	8.4
IE Group #4 - 4 semesters (Fall 1985, Spring, 1986, Fall 1986, Spring 1987) (N=11)	726.5	11.8

ANOVA comparing controls to all IE students
F = 5.3293 p = .0240

ANOVA comparing 2 semesters versus 4 semesters exposure
F = 1.3275 p = .2571

Table 6.

Selected Two-Way Analysis of Variance Models, I.E. Students

IE Group Status by Age-at-Onset of Hearing Loss

	Overall Sample	IE Group Hearing Loss Under 2 Yrs.	IE Group Hearing Loss 2+ Years	Control Group Hearing Loss Under 2 Yrs.	Control Group Hearing Loss 2+ Yrs.
Raven's					
- Pre	44.9 (54)	46.1 (21)	44.8 (13)	42.9 (12)	45.4 (8)
- Post	46.5 (54)	47.4 (21)	47.6 (13)	44.0 (12)	46.5 (8)
- Difference	1.6 (54)	1.3 (21)	2.8 (13)	1.1 (12)	1.1 (8)

IE Group Status by Sex of Student

	Overall Sample	IE Group Males	IE Group Females	Control Males	Control Females
Raven's					
- Pre	44.5 (66)	45.9 (22)	44.3 (16)	47.3 (12)	40.6 (16)
- Post	46.2 (66)	48.2 (22)	46.0 (16)	48.0 (12)	42.3 (16)
- Difference	1.7 (66)	2.3+ (22)	1.7 (16)	0.7 (12)	1.7 (16)
SAT Math					
Concepts	690.3 (53)	709.6* (16)	694.3 (9)	690.5 (12)	668.7 (16)
Computation	705.0 (66)	725.7* (16)	701.4 (16)	707.1 (12)	678.4 (16)

\+ Denotes IE males' subgroup mean is significantly higher ($p < .05$) than Control males.
* Denotes sub-group mean is significantly higher ($p < .05$) than overall mean.